Labs21: Improving the Performance of U.S. Laboratories

Dale Sartor
Lawrence Berkeley National Laboratory

Laboratory Buildings

"Labs embody the spirit, culture, and economy of our age… what the cathedral was to the 14th century and the office building was to the 20th century, the laboratory is to the 21st century."

Don Prowler

College of Engineering, Rowan University

LABS FOR THE 21ST CENTURY

Energy Use at Laboratories

- Laboratories are energy intensive.
  - On a square foot basis, labs often consume four to six times as much energy as a typical office building.
- Most existing labs can reduce energy use by 30%-50% with existing technology.
- Laboratories are experiencing significant growth.
- Energy cost savings possible from U.S. labs may be as much as $1 billion to $2 billion annually.

LABS FOR THE 21ST CENTURY

What is Labs21?

- A joint EPA/DOE partnership program to improve the environmental performance of U.S. laboratories.
- Encourages the design, construction, and operation of sustainable, high-performance facilities that will:
  - Minimize overall environmental impacts.
  - Protect occupant safety.
  - Optimize whole building efficiency on a lifecycle basis.

Labs21 Goals

- Improve energy efficiency and performance of new and existing laboratories through targeted **technical assistance**
- Increase **capacity-building** in the laboratory sector through training and peer-to-peer information exchange

Labs21: A Vibrant Program

- Growing network of more than 3,500 laboratory designers, engineers, facility/energy managers, health and safety personnel, and others.
- Trained thousands of professionals.
- Attracts over 500 attendees to the annual international conference.
- Actively working with dozens of Partners and Supporters.
- Partnering with Centers of Excellence to expand technical capacity and program reach.

Labs21 Program Components

1. Partnership Program
   – Draws together lab owners and designers committed to implementing high performance lab design.
2. Training Program
   – Includes annual technical conference, training workshops, and other peer-to-peer opportunities.
3. Best Practices and Tool Kit
   – An Internet-accessible compendium of case studies and other information on lab design and operation, building on the *Design Guide for Energy Efficient Research Laboratories* developed by Lawrence Berkeley National Laboratory, and more...

Component #1: Partnership Program

- EPA and DOE are partnering with interested lab owners.
- Working with Labs21, each partner will:
  - Set voluntary goals.
  - Assess the opportunities for improvements.
  - Measure and report progress.

LABS FOR THE 21ST CENTURY

Benefits of Partnership

- Technical Assistance
  - Participation in sustainable design charrettes
  - Advice on specific technical issues (e.g. heat recovery, fume hoods)
  - Help using Labs21 toolkit
- Networking
  - Opportunities to network and share results with peers
- National recognition
  - Thru Labs21 events, awards, and promotional materials

LABS FOR THE 21ST CENTURY

Partnership Requirements

- Adopt the Labs21 principles.
- Commit to a specific project (new or retrofit).
- Develop a method to measure and evaluate success.
- Grant Labs21 permission to publicize partnership activities.
- Participate in the annual Labs21 conference.

LABS FOR THE 21ST CENTURY

Labs21 Partners

Private Sector Partners

- Bristol-Myers Squibb
- Carnegie Mellon University
- Duke University
- Genzyme
- Harvard University
- New York City Public School Authority
- Northern Arizona University
- Pfizer
- Raytheon
- Sonoma State University
- University of California – Merced
- University of Hawaii
- University of North Carolina – Asheville
- Wyeth-Ayerst Pharmaceuticals

LABS FOR THE 21ST CENTURY

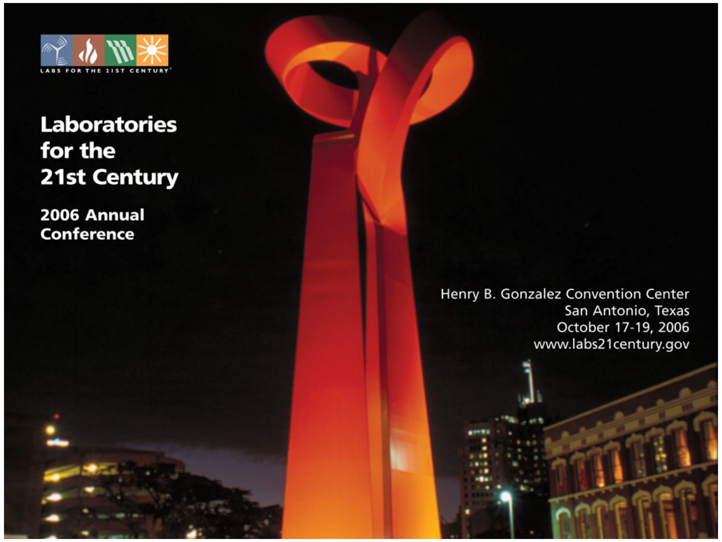
Labs21 Federal Partners

- Lawrence Berkeley National Laboratory
- National Aeronautics & Space Administration
- National Oceanic & Atmospheric Administration
- National Renewable Energy Laboratory
- National Science Foundation
- Sandia National Laboratories
- U.S. Department of Agriculture
- U.S. Environmental Protection Agency

LABS FOR THE 21ST CENTURY

Component #2: Training

- A comprehensive education and training program that targets:
  - Design professionals.
  - Laboratory O&M management.
  - Energy managers.
- Annual conference
- One day introductory course
- Advanced course modules
  - LEED for Labs
  - Lab ventilation
- Phone forums on specific topics
- Video with case studies
- Student design competition
- Partnership with UC/CSU/IOU’s



October 17-19, 2006

Henry B. Gonzalez Convention Center

San Antonio, TX

Labs21 Training and TA is focused on unique challenges and opportunities in Labs

- VAV fumehoods
- Low flow fumehoods
- Energy recovery
- Minimizing reheat
- Low pressure drop design
- Multi-stack exhaust

- Fumehood and laboratory Commissioning
- Indoor air flow modeling

- Optimizing air change rates
- Effluent dispersion
- Plug loads and rightsizing
- Lab equipment efficiency

- Daylighting in labs
- Effective electrical lighting design
- Flexible servicing configurations
- Green materials for labs

LABS FOR THE 21ST CENTURY

Component #3: Toolkit

- *For an overview*
  - Intro to Low-Energy Design
  - Video
- *Core information resources*
  - Design Guide
  - Case Studies
  - Energy Benchmarking
  - Best Practice Guides
- *Design process tools*
  - Env. Performance Criteria
  - Design Intent Tool
  - Labs21 Process Manual

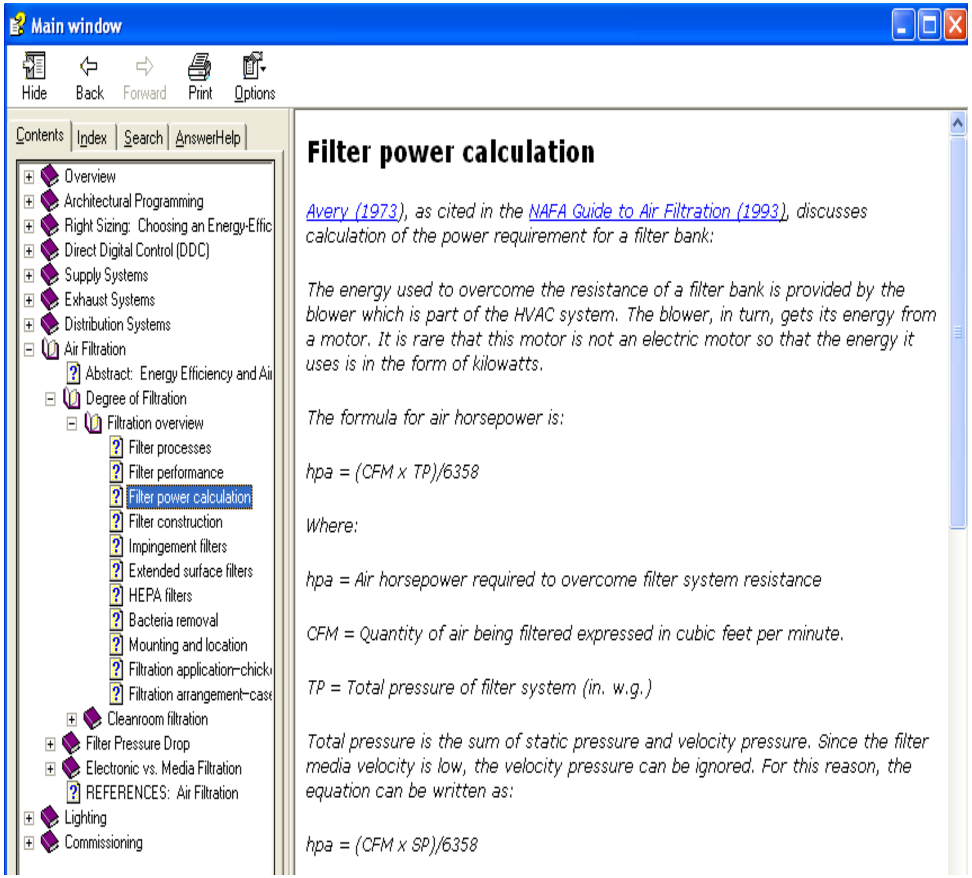
www.labs21century.gov/toolkit

LABS FOR THE 21ST CENTURY

Core information resources

Lab Design Guide

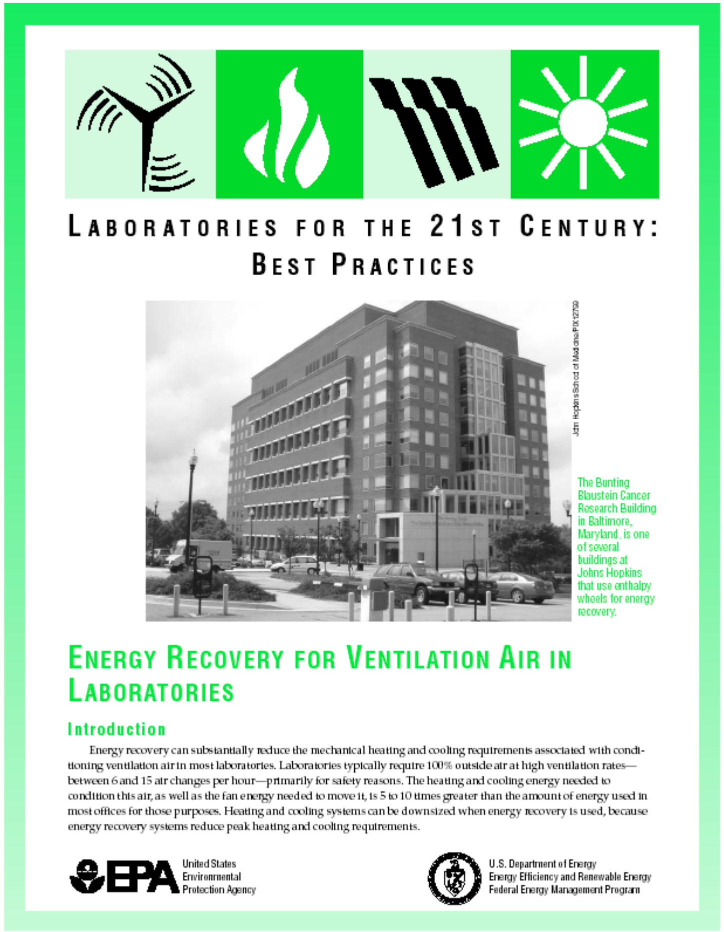
- A detailed reference on high-performance, low-energy lab design and operation
- 4-level hierarchy – from general to specific
- Searchable
- Available on web and CD



Core information resources

Best Practice Guides

- Describes how to implement a strategy, with implementation examples
- Completed guides:
  - Combined Heat and Power
  - Daylighting in Laboratories
  - Energy Recovery
  - Low-pressure drop design
  - Modeling Exhaust Dispersion
  - Water Efficiency
  - Minimizing Reheat
  - Right-sizing
- Several in development
  - Labs21 seeking contributing authors



LABORATORIES FOR THE 21ST CENTURY: BEST PRACTICES

The Bunting Blaustein Cancer Research Building in Baltimore, Maryland, is one of several buildings at Johns Hopkins that use enthalpy wheels for energy recovery.

ENERGY RECOVERY FOR VENTILATION AIR IN LABORATORIES

Introduction

Energy recovery can substantially reduce the mechanical heating and cooling requirements associated with conditioning ventilation air in most laboratories. Laboratories typically require 100% outside air at high ventilation rates—between 6 and 15 air changes per hour—primarily for safety reasons. The heating and cooling energy needed to condition this air, as well as the fan energy needed to move it, is 5 to 10 times greater than the amount of energy used in most offices for those purposes. Heating and cooling systems can be downsized when energy recovery is used, because energy recovery systems reduce peak heating and cooling requirements.

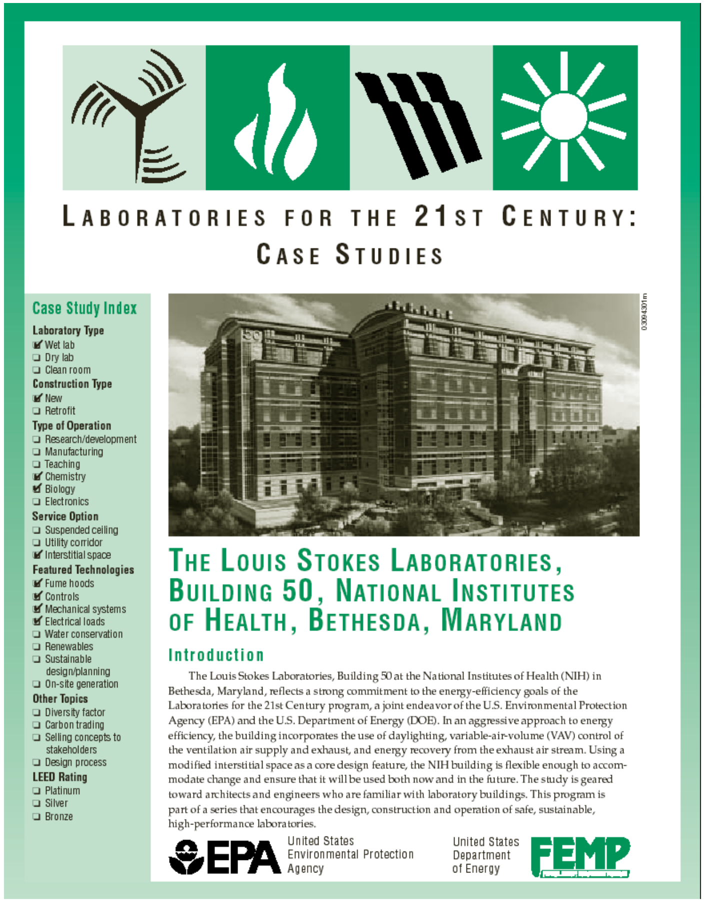
United States Environmental Protection Agency

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Federal Energy Management Program

Case Studies

- Bren Hall, UCSB
- Fred Hutchinson Cancer Research Center
- Georgia Public Health Laboratory
- Haverford College Natural Science Center
- National Institutes of Health Building 50
- Sandia National Laboratories PETL
- Nidus Center
- Pharmacia Building Q
- U.S. EPA National Vehicle and Fuel Emissions Lab
- Whitehead Biomedical Research Center, Emory University

All case studies have whole-building and system level energy use data


LABORATORIES FOR THE 21ST CENTURY: CASE STUDIES

Case Study Index

Laboratory Type
- ☑ Wet lab
- ☐ Dry lab
- ☐ Clean room

Construction Type
- ☑ New
- ☐ Retrofit

Type of Operation
- ☐ Research/development
- ☐ Manufacturing
- ☐ Teaching
- ☑ Chemistry
- ☑ Biology
- ☐ Electronics

Service Option
- ☐ Suspended ceiling
- ☐ Utility corridor
- ☑ Interstitial space

Featured Technologies
- ☑ Fume hoods
- ☑ Controls
- ☑ Mechanical systems
- ☑ Electrical loads
- ☐ Water conservation
- ☐ Renewables
- ☐ Sustainable design/planning
- ☐ On-site generation

Other Topics
- ☐ Diversity factor
- ☐ Carbon trading
- ☐ Selling concepts to stakeholders
- ☐ Design process

LEED Rating
- ☐ Platinum
- ☐ Silver
- ☐ Bronze

THE LOUIS STOKES LABORATORIES, BUILDING 50, NATIONAL INSTITUTES OF HEALTH, BETHESDA, MARYLAND

Introduction

The Louis Stokes Laboratories, Building 50 at the National Institutes of Health (NIH) in Bethesda, Maryland, reflects a strong commitment to the energy-efficiency goals of the Laboratories for the 21st Century program, a joint endeavor of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). In an aggressive approach to energy efficiency, the building incorporates the use of daylighting, variable-air-volume (VAV) control of the ventilation air supply and exhaust, and energy recovery from the exhaust air stream. Using a modified interstitial space as a core design feature, the NIH building is flexible enough to accommodate change and ensure that it will be used both now and in the future. The study is geared toward architects and engineers who are familiar with laboratory buildings. This program is part of a series that encourages the design, construction and operation of safe, sustainable, high-performance laboratories.

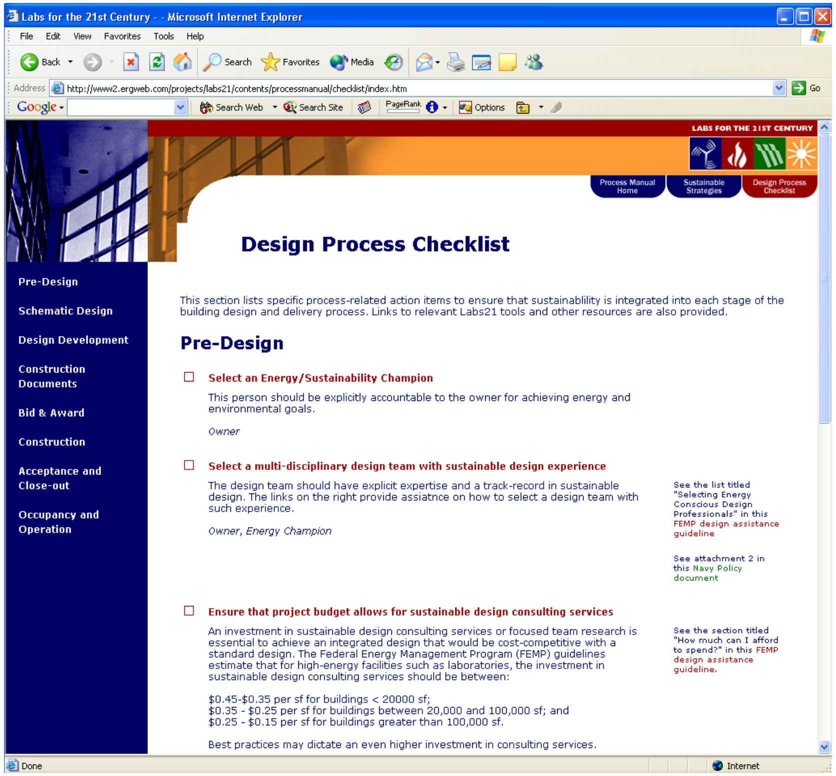
EPA United States Environmental Protection Agency

United States Department of Energy FEMP

LABS FOR THE 21ST CENTURY

Process Manual

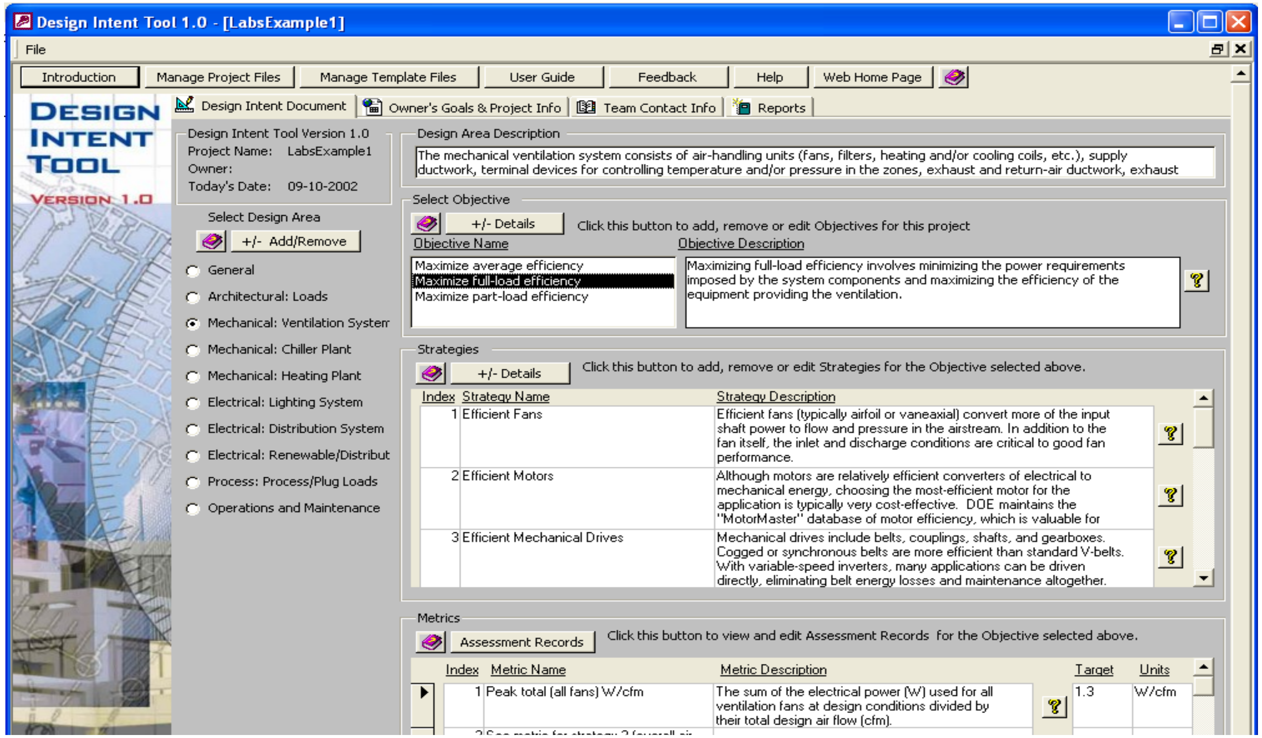
- Provides design process guidance
- Action items for each stage of design process
  - Links to appropriate tools and resources
- Checklist of sustainable design strategies
  - Portal to core information resources
  - Useful for design charrettes



LABS FOR THE 21ST CENTURY

Design Intent Tool

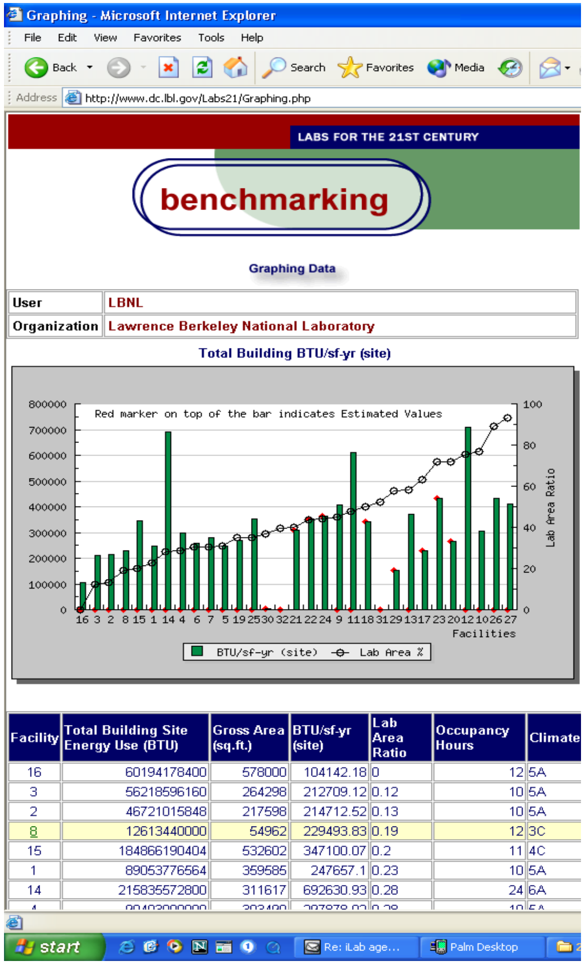
- A database tool to document intended strategies and metrics during design



LABS FOR THE 21ST CENTURY

Energy Benchmarking Tool

- National database of lab energy use data
- Web-based input and analysis
- About 70 facilities
- Building level data (e.g. Site BTU/sf)
- System level data (e.g. W/cfm)
- Why benchmark?
  - See where you stand
  - Set targets

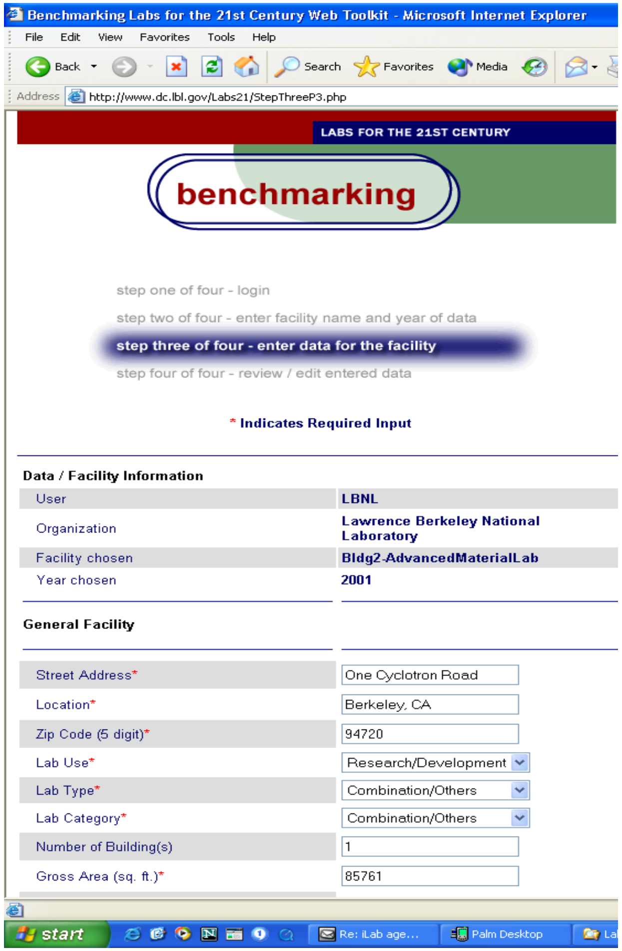


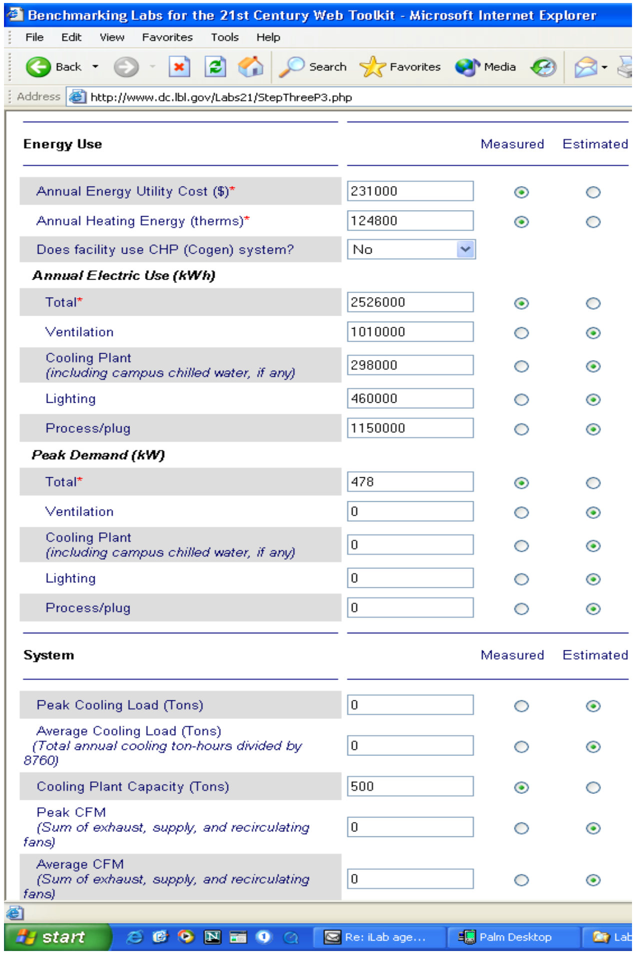
LABS FOR THE 21ST CENTURY

Benchmarking Metrics

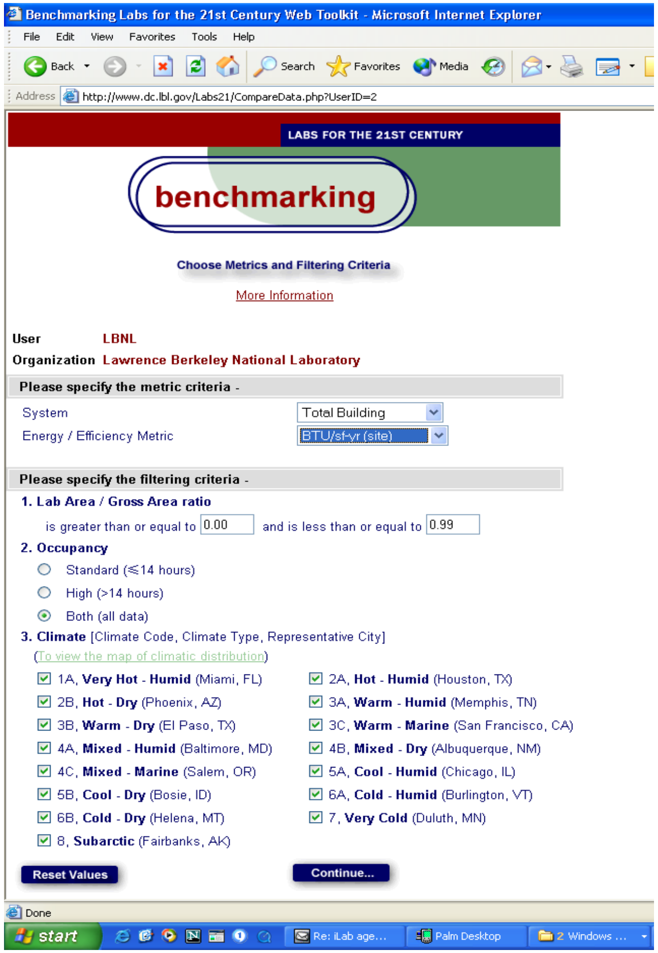
System	Energy Consumption	Energy Demand
Ventilation	kWh/sf-yr	Peak W/cfm Peak cfm/sf (lab) Avg cfm/peak cfm
Cooling	kWh/sf-yr	Peak W/sf Peak sf/ton kW/ton
Lighting	kWh/sf-yr	Peak W/sf
Process/Plug	kWh/sf-yr	Peak W/sf
Heating	BTU/sf-yr	Peak W/sf
Aggregate	kWh/sf-yr (total elec) BTU/sf-yr (site) BTU/sf-yr (source) Utility $/sf-yr	Peak W/sf Effectiveness (Ideal/Actual)

Labs21 Benchmarking Tool – Data Input



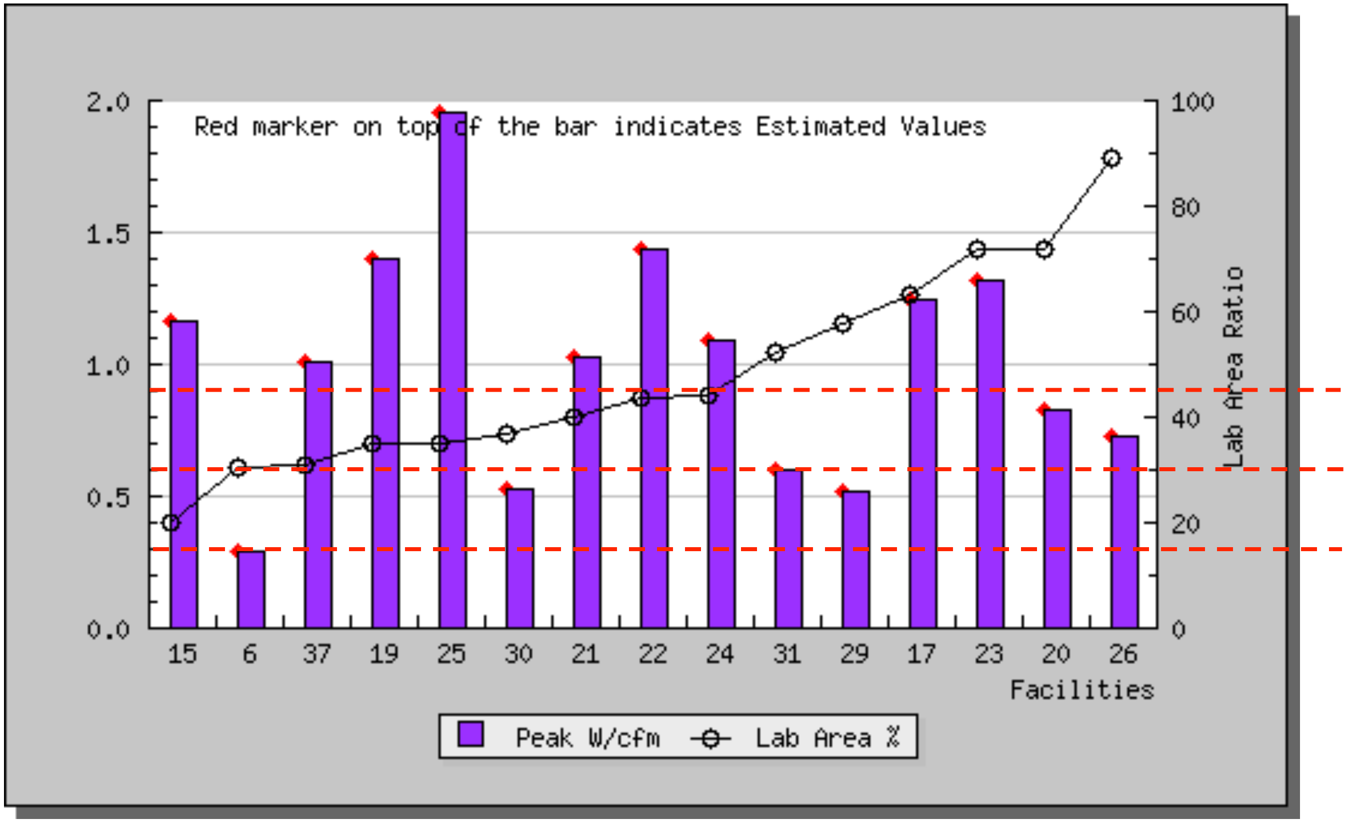


Labs21 Benchmarking Tool – Analysis



Facility	Total Building Site Energy Use (BTU)	Gross Area (sq.ft.)	BTU/sf-yr (site)	Lab Area Ratio	Occupancy Hours	Climate
8	12613440000	54962	229493.83	0.19	12	3C
15	184866190404	532602	347100.07	0.2	11	4C
6	14396064000	55903	257518.63	0.3	12	3C
7	12350320000	44152	279722.78	0.31	12	3C
5	21098712000	85761	246017.56	0.31	12	3C
19	40723337460	151435	268916.28	0.35	12	4B
30	5198674400	21018	247343.91	0.37	24	3C

Labs21 Benchmarking Tool – Vent. W/cfm



Standard, good, better benchmarks as defined in
“How-low Can You go: Low-Pressure Drop Laboratory Design”
by Dale Sartor and John Weale

Environmental Performance Criteria (EPC)

- A rating system for evaluating laboratory design.
  - Builds on the LEED™ rating system
- Adds credits and prerequisites pertaining to labs
  - Health & Safety
  - Fumehood energy use
  - Plug loads
- Leveraged volunteer efforts
  - > 40 architects, engineers, facility managers, and health and safety personnel.
  - > 200 person hours contributed
- USGBC developing LEED for Labs based on EPC

EPC & LEED

Yes	?	No			
				Indicates additions/modifications to LEED	
0	**0**	**0**		**Sustainable Sites**	**16**
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Urban Redevelopment**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
			Credit 6.1	**Stormwater Management**, Rate or Quantity	1
			Credit 6.2	**Stormwater Management**, Treatment	1
			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
			Credit 8	**Light Pollution Reduction**	1
			Credit 9.1	**Safety and Risk Management**, Air Effluent	1
			Credit 9.2	**Safety and Risk Management**, Water Effluent	1
Yes	?	No			
0	**0**	**0**		**Water Efficiency**	**7**
Y			Prereq 1	**Laboratory Equipment Water Use**	Required
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
			Credit 2	**Innovative Wastewater Technologies**	1

How to Become Involved

- Contact:
  Dan Amon
  U.S. EPA
  (202) 564-7509
  Amon.Dan@epamail.epa.gov

- Visit: www.labs21century.gov
- E-mail the Labs21 Network: labs21@erg.com

LABS FOR THE 21ST CENTURY

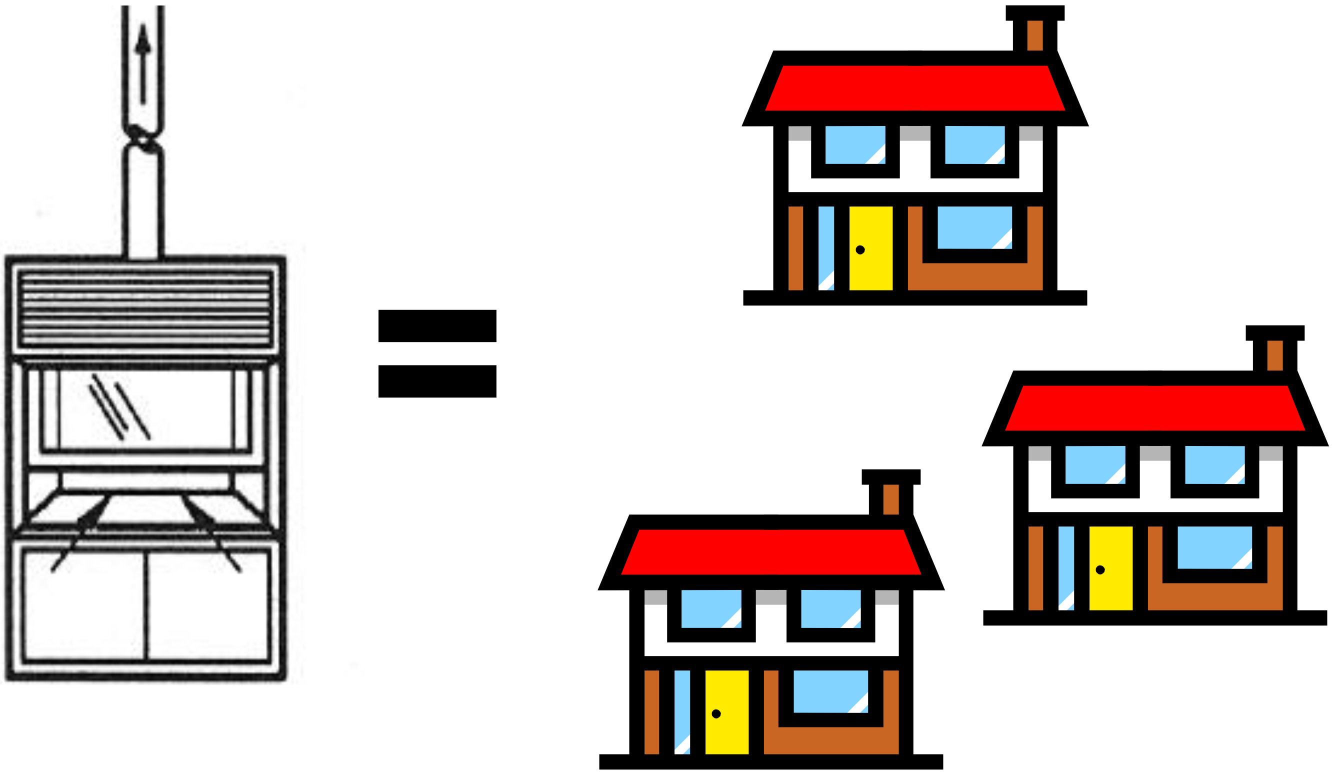
More detail on specific best practices: Five **BIG HITS**

1. Tame the hoods
2. Scrutinize the air changes
3. Drop the pressure drop
4. Get real with plug loads
5. Just say no to re-heat

LABS FOR THE 21ST CENTURY

1. Tame the Hoods

Fume Hood Energy Consumption



Tame the Hoods

- Reduce number, size, and opening (restricted sash) to that required
- Design for easy removal and additions
- Use VAV or two "speed"
- Consider high performance fume hoods and better commissioning (e.g. tracer gas testing)

2. Scrutinize the Air Changes

- Don't assume air changes are driven by thermal loads
- What do you use as minimum ACH?
  - Why? Why? Why?
- When is ten or more air changes safe and six air changes (or less) not?
- Consider a panic switch concept
- Why is the same air change rate needed when a lab is unoccupied?
- Very large peak and operating cost impact

3. Drop the Pressure Drop

- Up to one half HVAC energy goes to fans
- How low can you go

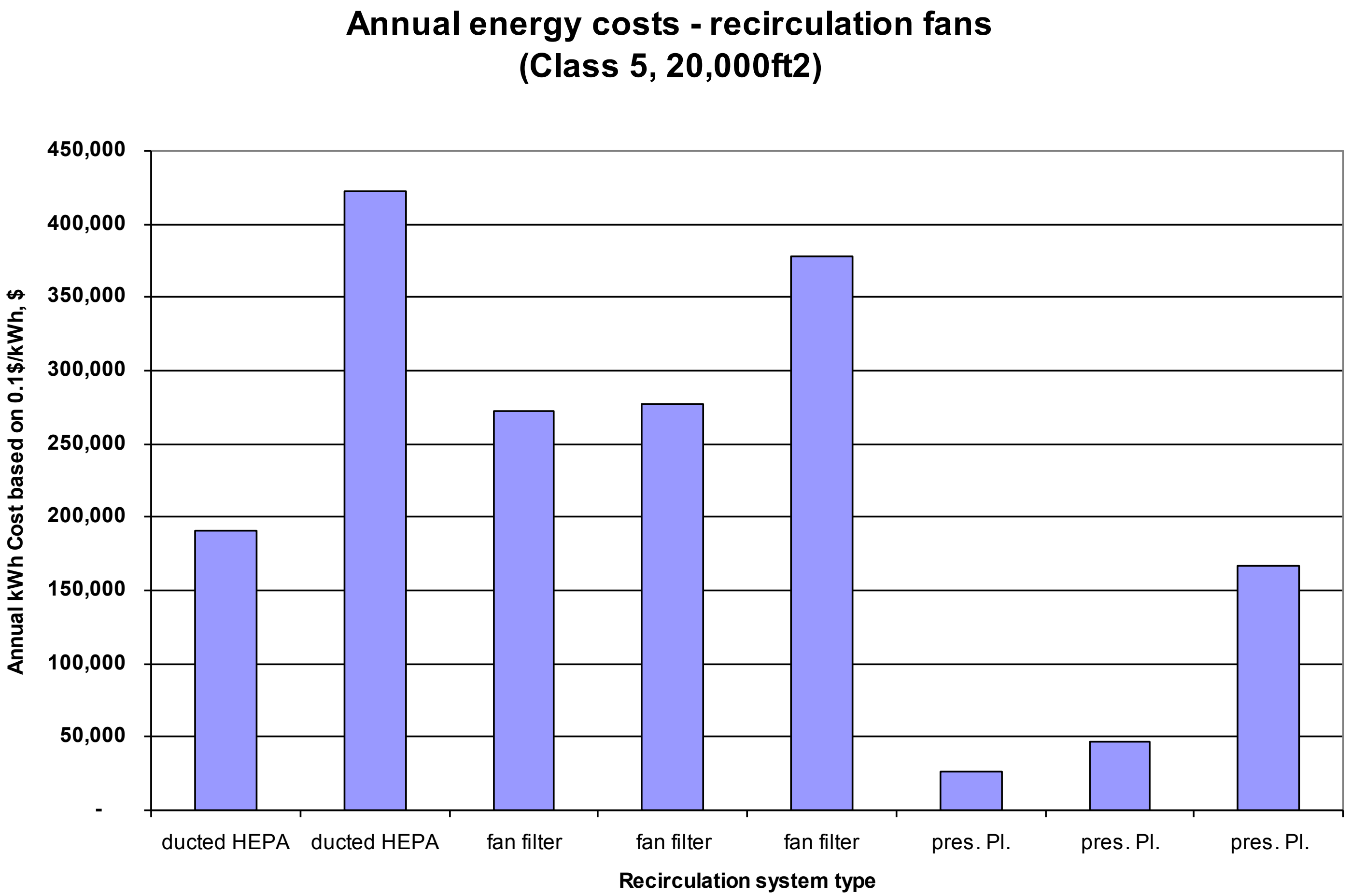
Low Pressure-Drop Design Guidelines

Component	Standard	Good	Better
Air handler face velocity	500	400	300
Air Handler	2.5 in. w.g.	1.5 in. w.g.	0.75 in.w.g.
Heat Recovery Device	1.00 in. w.g.	0.60 in. w.g.	0.35 in. w.g.
VAV Control Devices	Constant Volume, N/A	Flow Measurement Devices, 0.60 - 0.30 in. w.g.	Pressure Differential Measurement and Control, 0.10 in. w.g.
Zone Temperature Control Coils	0.5 in. w.g.	0.30 in. w.g.	0.05 in. w.g.
Total Supply and Return Ductwork	4.0 in. w.g.	2.25 in. w.g.	1.2 in. w.g.
Exhaust Stack CFM and	0.7” w.g. full design flow through entire exhaust system, Constant Volume	0.7” w.g. full design flow through fan and stack only, VAV System with bypass	0.75” w.g. averaging half the design flow, VAV System with multiple stacks
Noise Control (Silencers)	1.0” w.g.	0.25” w.g.	0.0” w.g.
Total	**9.7” w.g.**	**6.2” w.g.**	**3.2” w.g.**
Approximate W / CFM	**1.8**	**1.2**	**0.6**

Source: J. Weale, P. Rumsey, D. Sartor, L. E. Lock, “Laboratory Low-Pressure Drop Design,” ASHRAE Journal, August 2002.

LABS FOR THE 21ST CENTURY

Annual Energy Cost for Cleanroom Recirculation Fans

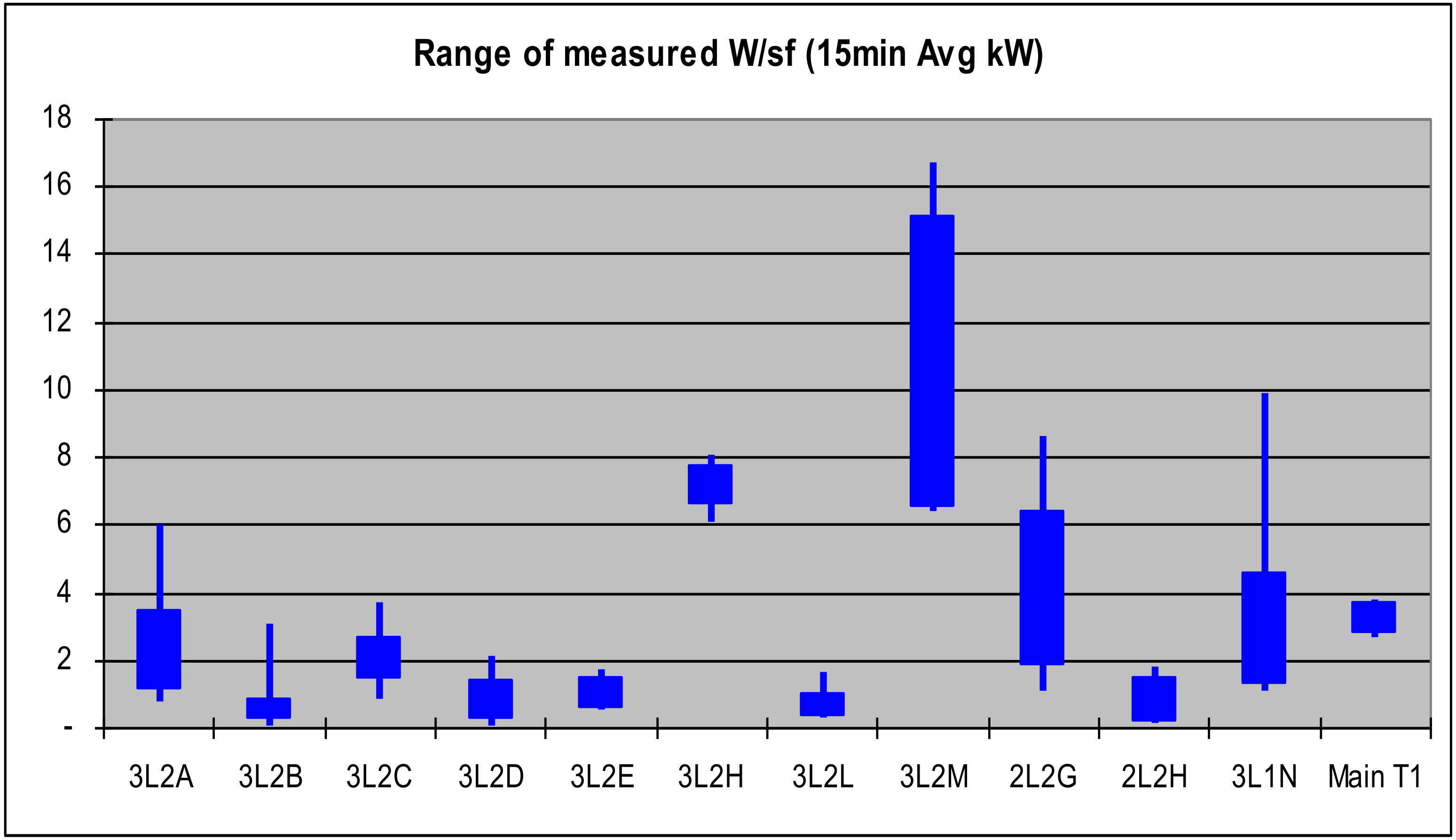


4. Get Real with Plug Loads

- Save capital cost and operating cost
- Measure actual loads in similar labs
- Design for high part load efficiency
  - Modular design approaches

- Plug load diversity in labs increases reheat

Measured Plug Loads



UC Davis – 16-58 W/sf design

5. Just Say No to Reheat

- Reheat results in energy waste in labs
  - High-load areas require lower supply air temperature, so reheat occurs in other spaces
- Simultaneous heating and cooling can be much more problematic in a lab where the variations of internal loads can be enormous
- When reheat is employed, a single zone requiring cooling can create artificial heating and cooling loads throughout the building
- Some possible solutions are:
  - Put cooling coils or cooling fan coils in each zone.
  - Use a dual duct system with cool duct and neutral (70 deg. +/-) duct.

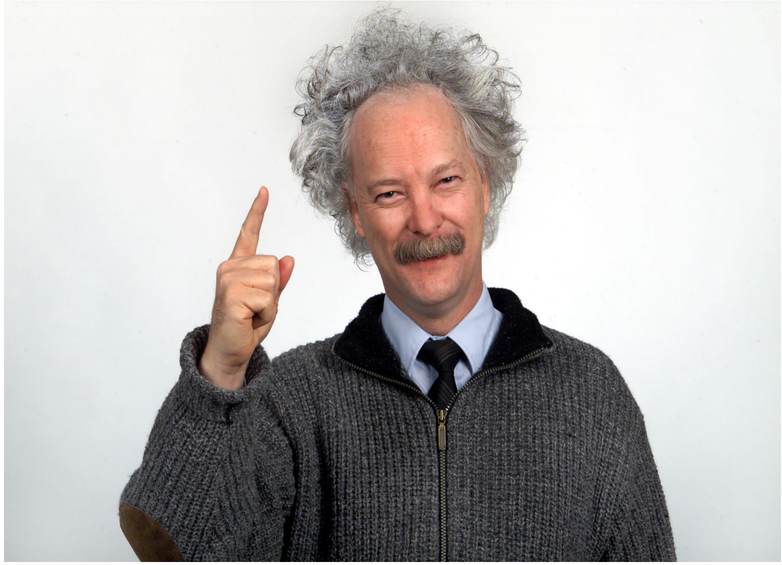
LABS FOR THE 21ST CENTURY

Contact Information:

Dale Sartor, P.E.

Lawrence Berkeley National Laboratory
Applications Team
MS 90-3011
University of California
Berkeley, CA 94720

DASartor@LBL.gov
(510) 486-5988
http://Ateam.LBL.gov



LABS FOR THE 21ST CENTURY